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[54] **PROCESS FOR THE TREATMENT OF SOOT PARTICLES AND THE CLEANING OF EXHAUST GASES OF AN INTERNAL COMBUSTION ENGINE AND APPARATUS FOR ITS PRACTICE**

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[52] **U.S. Cl.** **60/274;** 60/275; 60/297; 60/303; 422/170; 422/174
[58] **Field of Search** 60/303, 274, 275, 297; 422/170, 171, 174

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,404,795	9/1983	Oishi	60/303
4,450,682	5/1984	Sato	60/303
4,649,703	3/1987	Dettling	60/275
4,852,349	8/1989	Abthoff	60/303

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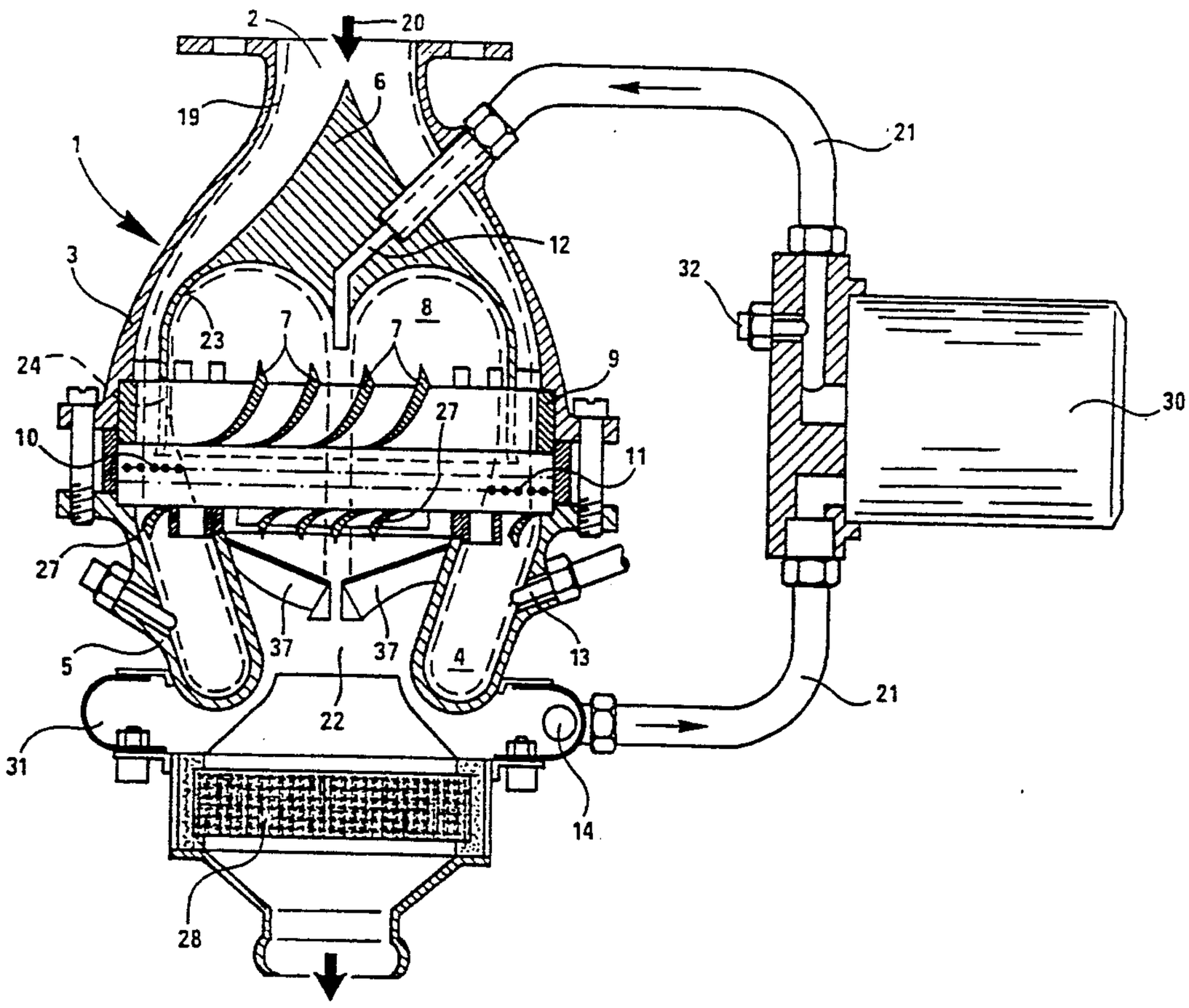
[57] **ABSTRACT**

Heretofore, soot particles are removed from exhaust gases of an internal combustion engine by means of a ceramic filter, which must periodically be replaced, namely, each time it is used up. The new apparatus is to remove soot particles continually from the exhaust gases without diminishing the filtering action. In a two-part casing there are provided for the exhaust gases, in a first casing half with the inlet and in a second casing half with the outlet, a first deflector chamber for the exhaust gases. In the first casing half there is located a quiescent zone for the exhaust gases and—surrounded by the two casing halves—a heating system which is flown through three times by the exhaust gases. The apparatus produces a strong combustion of the soot particles present in the exhaust gases and is not subject to any exhaustion, since it does not store soot particles but burn the same as much as possible.

25 Claims, 3 Drawing Sheets



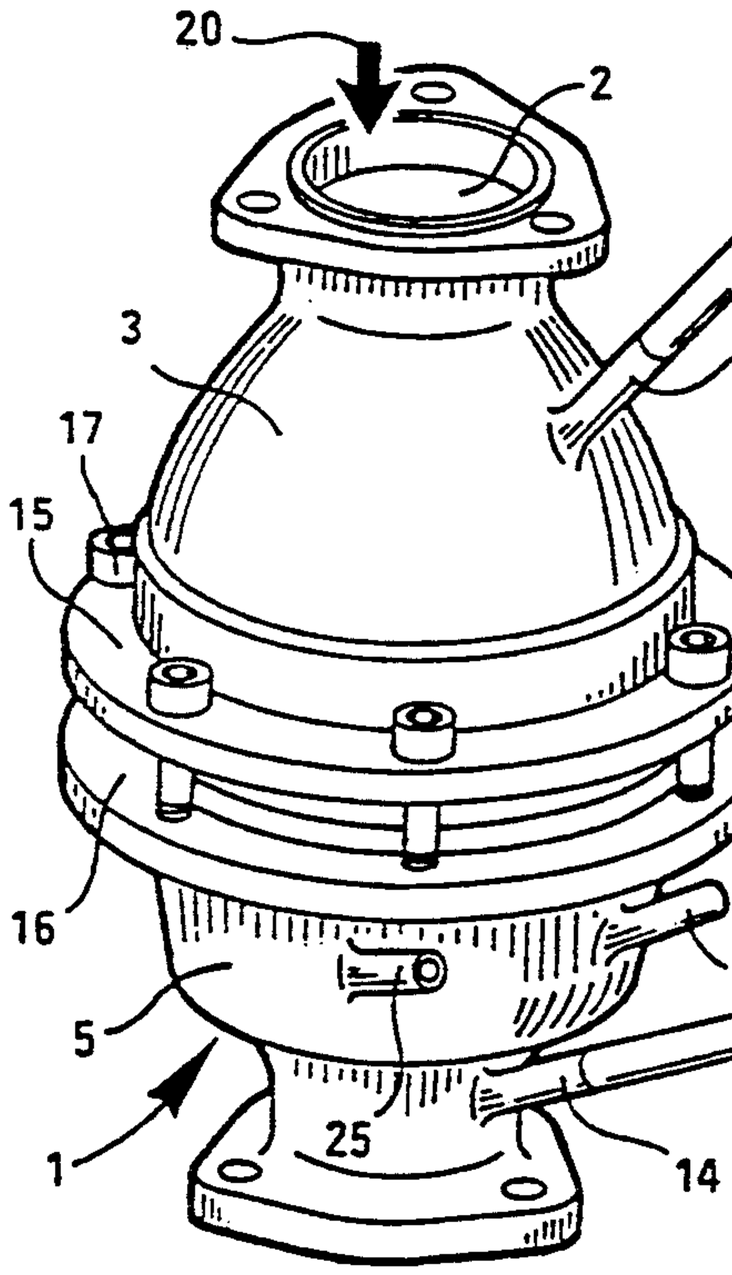

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Fig.1

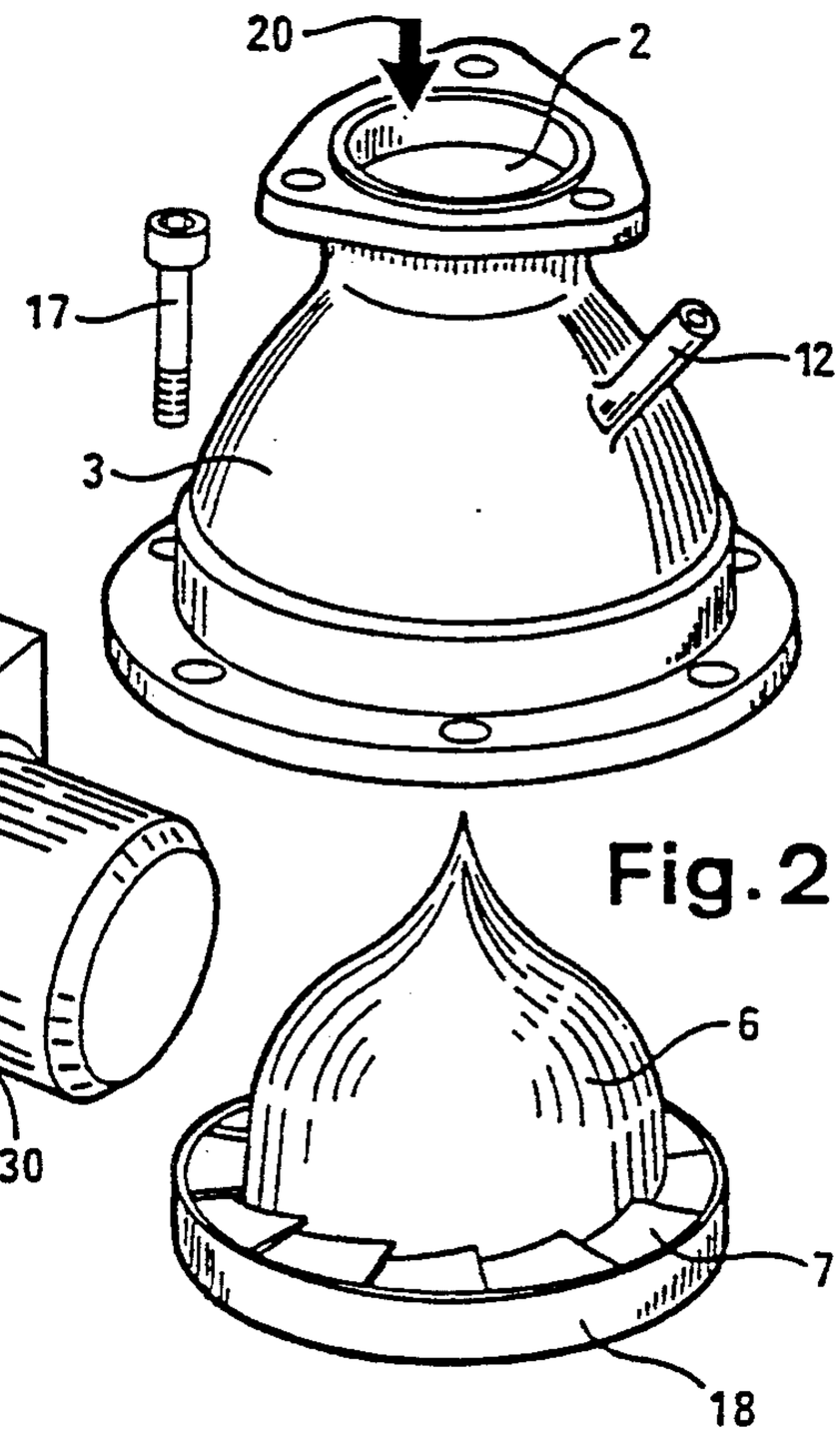
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Fig.2

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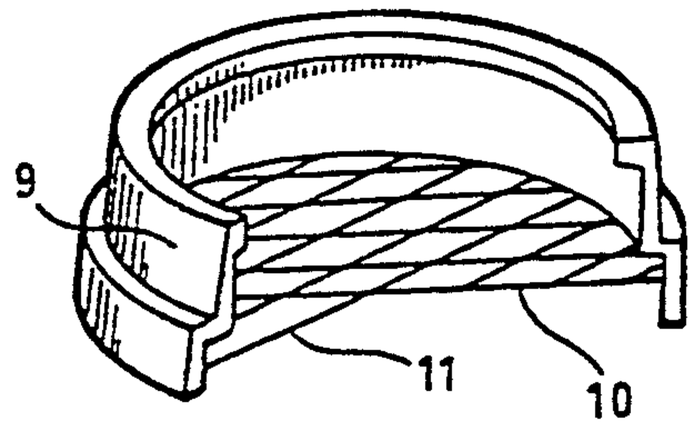
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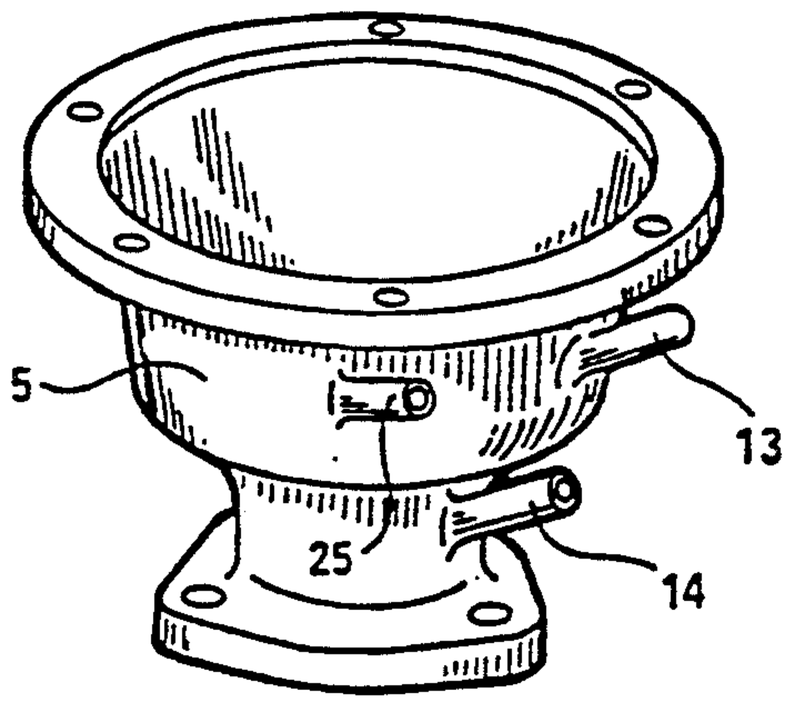
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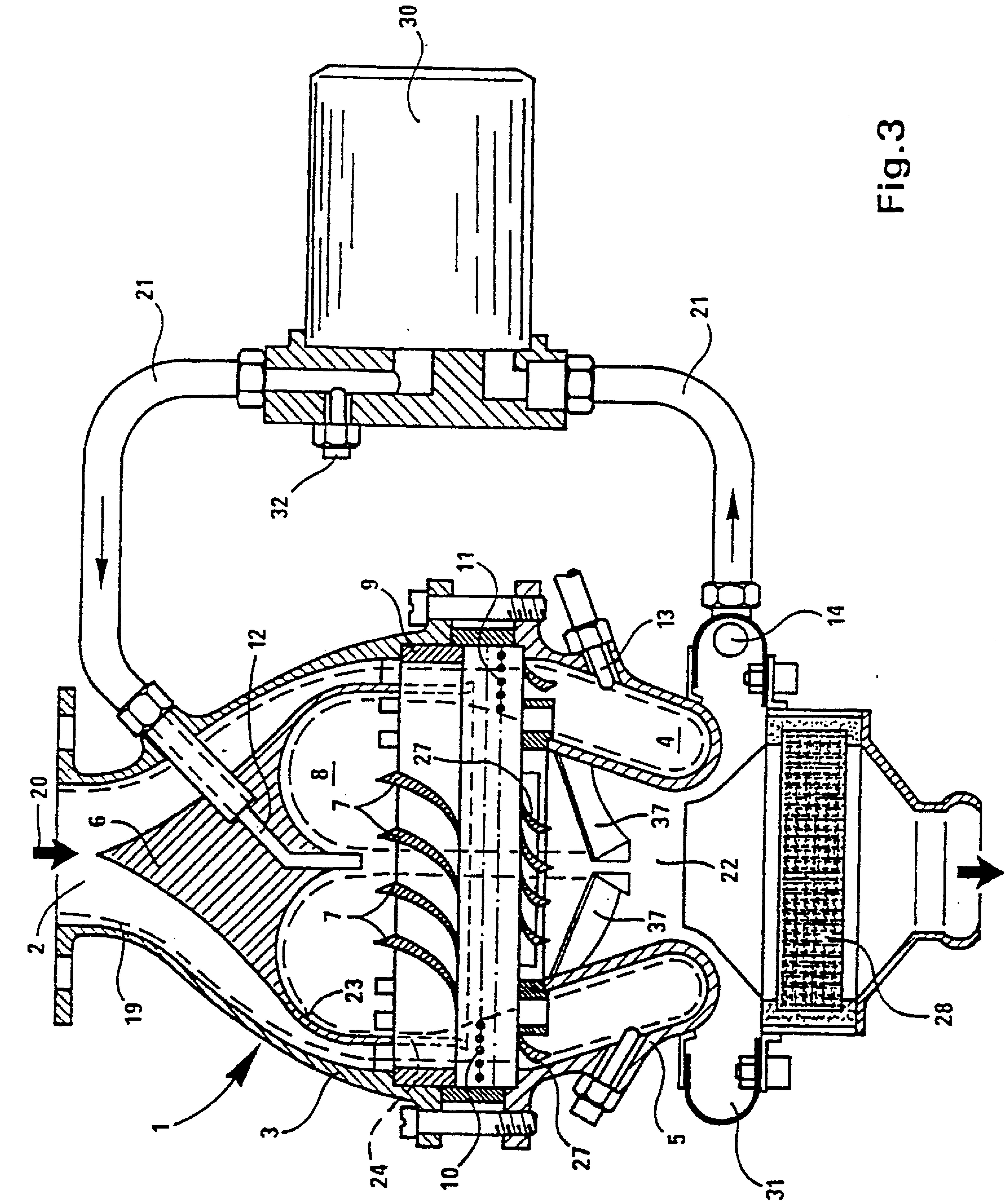
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Fig.3

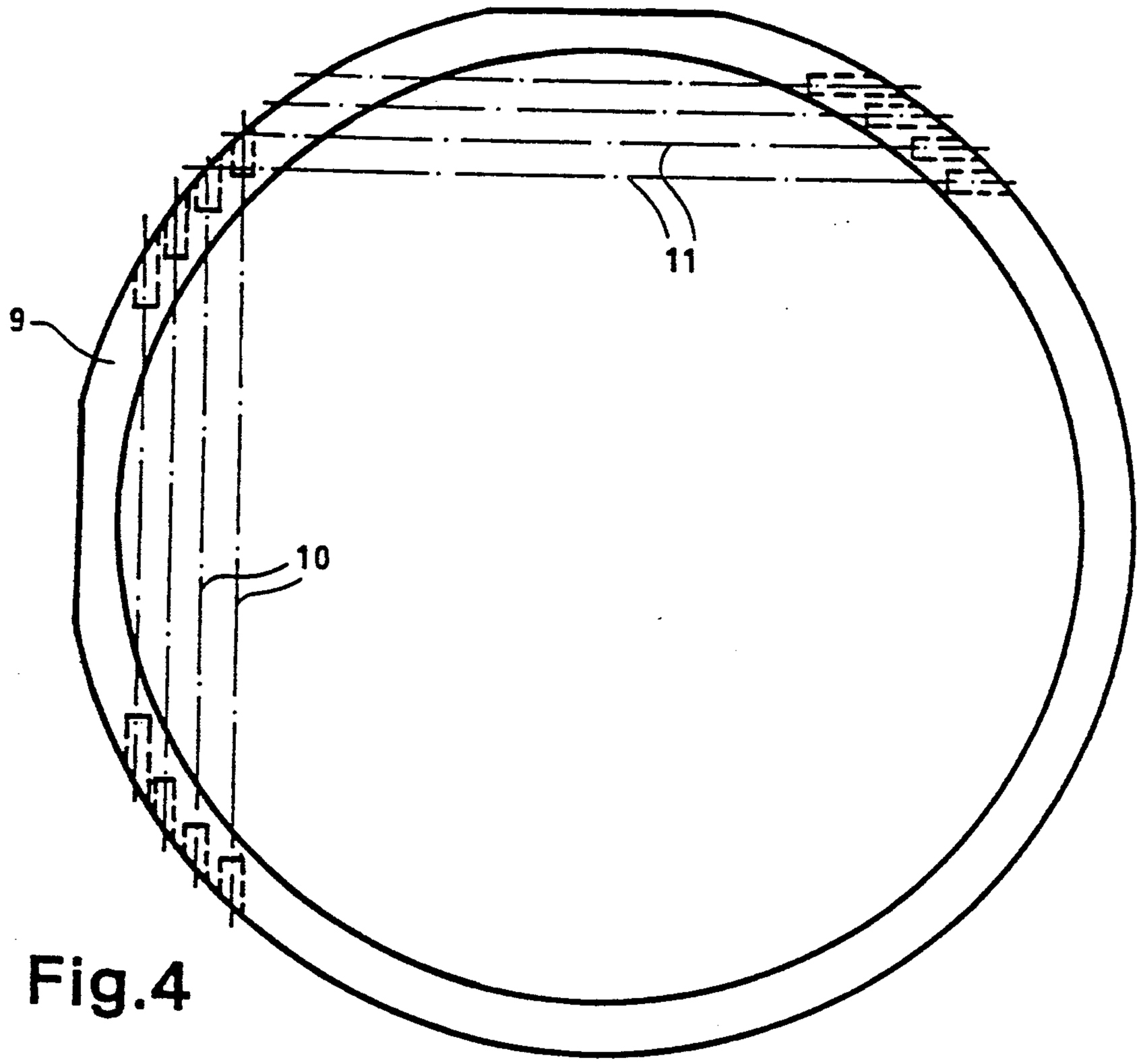

Fig.4

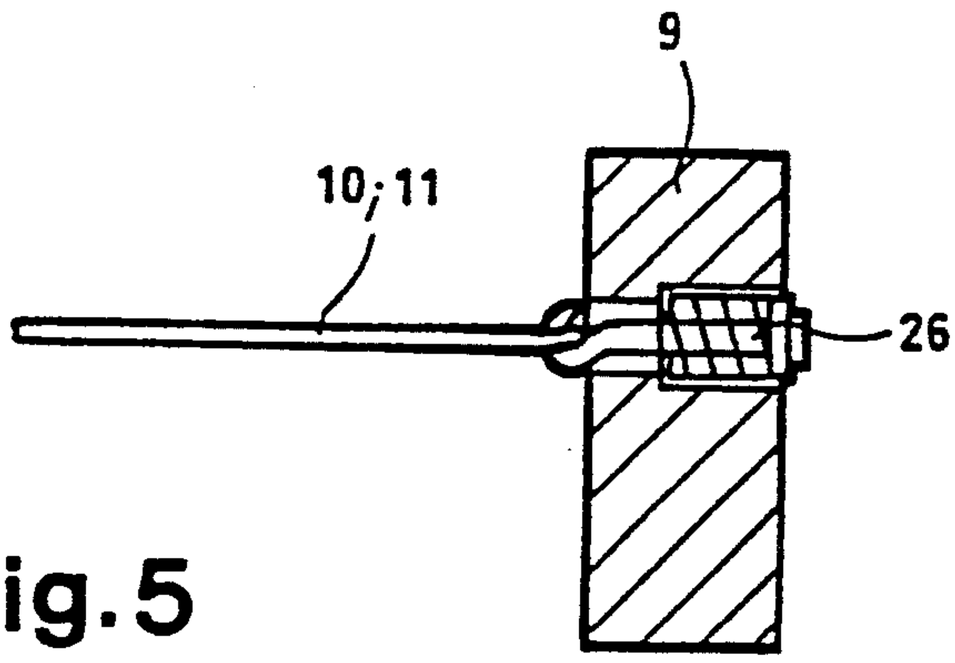

Fig.5

PROCESS FOR THE TREATMENT OF SOOT PARTICLES AND THE CLEANING OF EXHAUST GASES OF AN INTERNAL COMBUSTION ENGINE AND APPARATUS FOR ITS PRACTICE

The invention relates to a process for the treatment of soot particles and the cleaning of exhaust gases of an internal combustion engine and an apparatus for its practice.

West German Laid-open Application 3,502,448 discloses an apparatus for the removal of soot particles and other solid particles from the exhaust gas of motor vehicles, which apparatus contains a soot collector that must be freed of soot through a disposal nozzle. This apparatus has the disadvantage that it is not operative if the soot collector has become completely filled with soot. The soot collector must be cleaned out periodically and results in downtimes for the vehicle concerned.

The object of the invention is to provide a process and an apparatus of the type mentioned in the introduction, with which it is possible continuously to remove soot particles from the exhaust gas of an internal combustion engine and to clean the exhaust gas without the necessity of periodically cleaning a filter.

The invention has the advantage over the prior art in that, during operation of the internal combustion engine concerned, its exhaust gases are continuously freed of soot particles, whereby a filter for residual soot particles becomes filled with soot only after long operating periods. The process brings about and the apparatus permits the elimination of the soot particles and thereafter the destructive oxidation of the residual hydrocarbon groups and combustion of the carbon monoxide into carbon dioxide, so that only water vapor, H_2O, and carbon dioxide, CO_2, are left as exhaust-gas constituents.

Further advantageous modifications of the invention will become apparent from the claims and the ensuing description.

The invention will be explained with reference to practical embodiments in conjunction with the drawings, in which

FIG. **1** is a perspective view of the apparatus in assembled condition;

FIG. **2** is a perspective exploded diagram of the apparatus;

FIG. **3** is a section through the apparatus in assembled condition;

FIG. **4** is a top plan view of a heating ring associated with the apparatus;

FIG. **5** is a view of a stay for a heating wire.

The apparatus contains, first, a casing **1** (FIG. **1**), which consists of two casing halves **3**, **5** held together by means of flanges **15**, **16** and bolts **17**. Here, bores with a diameter somewhat larger than that of the bolts are provided in one of the flanges **15**. The bolts **17** sit loosely, i.e., with play, in the bores. In the other flange **16**, threaded holes are provided into which the bolts **17** are screwed.

Before the two casing halves **3**, **5** are brought together, a heating ring **9** (FIG. **2**) and a flow cone **6** are inserted in the casing **1**.

The first casing half **3** (FIG. **3**) has an inlet **2** and the second casing half **5** has an outlet **22** for the exhaust gases. The flow cone **6** of the apparatus is inserted in the casing **1** such that its tip points toward the exhaust gases

flowing in through the inlet **2** of the apparatus. Gas deflector plates **7** are provided at one edge **18** (FIG. **2**) of the flow cone **6**. Exhaust gases arriving in the direction of arrow **20** (FIG. **3**) along a streamline **19** pass the inlet **2**, the space formed between the flow cone **6** and the wall of the upper casing half **3**, and the gas deflector plates **7** (FIG. **3**). The gas deflector plates **7** cause the exhaust gases to be swirled in a circular path along the outer wall of the casing **1**. The exhaust gases then pass through the electrically heated heating wires **10**, **11**, (FIGS. **2**, **3**, **4**), clamped in the heating ring **9**, at an angle to the gap between the heating wires **10** and the heating wires **11**, after which they arrive in a first deflection chamber **4** in the second casing half **5**. There, they impinge upon the outer wall of the second casing half **5** and, still swirling in a circular path corresponding to the outer wall of the second casing half **5**, are deflected in the first deflection chamber **4**. The exhaust gases are also directed toward the outer wall of the second casing half **5**, since they are deflected beforehand toward the outer wall of the second casing half **5** by an edge **24** spread gradually outward on the flow cone **6** .

After deflection of the exhaust gases in the deflection chamber **4**, they are passed for the second time — again at an angle — through the heating wires **10**, **11** clamped and heated in the heating ring **9**, and arrive at the inner surface **23** of the flow cone **6**, where they are deflected — while still being swirled in a circular ring — and passed from here for the third time — again at an angle — through the heated heating wires **10**, **11**.

Because the exhaust gases and especially the soot particles pass through the heated heating wires **10**, **11** three times and in the process sweep past the heating wires at an angle, intensive heating of the soot particles, which burn well as a result (pyrolysis), is achieved.

A line **12** leads from the inside of the flow cone **6** out of the first casing half **3**. The area in which the line **12** discharges into the deflection chamber **8** in the flow cone **6** constitutes a quiescent zone for the exhaust gases. From here, residues that remain after the three-stage combustion can be sucked out of the casing **1**. This is accomplished through a line **21** (FIGS. **1**, **3**), which is connected to a duct **14** in a space **31** (FIG. **3**) disposed downstream from the outlet of the casing **1**. A soot filter **30**, preferably in the form of a replaceable filter cartridge, is interposed in the line **21**.

During operation of the apparatus, an overpressure develops in the duct **14**, so that combustion residues, i.e., soot particles, still present at the outlet **22** are conveyed through the line **21** to the soot filter **30** and deposited thereat. It can be replaced if the soot filter **30** is saturated with soot particles and other combustion residues. A sensor **32** connected, for example, to an electronic system (not shown in the drawings), can monitor the degree of saturation of the soot filter **30**.

A duct **13** is used to supply fresh air, which is necessary when the engine adjustment is too rich. The supply of air into the deflection chamber **4** promotes the second and third combustion of the soot particles by the heating wires **10**, **11**. The control of the air supply to the duct **13**, and thus to the deflection chamber **4**, is provided by means known in themselves. Through another line **25** (FIGS. **1**, **2**), which also opens into the deflection chamber **4**, a sample of the exhaust-gas stream can be taken directly from the deflection chamber **4** and its condition checked by means of a sensor.

Gas deflector plates **27** are also provided in the area of the casing half **5** (FIG. **3**) for the purpose of swirling well the exhaust gases, which also entrain soot particles. Other gas deflector plates **37** are installed centrally upstream from the outlet.

The heating ring **9** bearing the heating wires **10, 11** consists of refractory ceramic material. In the practical embodiment, the heating wires **10, 11** are clamped between spring-loaded stays **26** (FIG. **5**). The spring-loaded stays **26** compensate for changes in length of the heating wires **10, 11** due to varying temperatures.

In one practical embodiment, the heating wires **10, 11** have developed temperatures of between 700 and 800° C.

The gas deflector plates **7** in one practical embodiment are inclined with an angle of attack of approximately 22° C. with respect to the planes in which the heating wires are located.

In another practical embodiment, the inclination of all gas deflector plates **7, 27, 37** can be changed if necessary, e.g., by bending the gas deflector plates.

The exhaust gases emerge from the casing **1** through its outlet **22** and arrive at an exhaust-gas filter **28** which is known in itself, for example, a catalyst in the form of a monolithic element.

The operation of an internal combustion engine in conjunction with the described apparatus can be achieved, first, by supplying the ignition electrodes, i.e., the heating wires **10, 11**, with current, thereby heating them up to high temperature. Only then will the internal combustion engine be started, thus ensuring excellent treatment and filtering-out of the soot particles as well as thorough cleaning of the exhaust gases.

The process for the treatment of soot particles and cleaning of exhaust gases of an internal combustion engine consists in moving exhaust gases containing soot particles past one or more ignition electrodes heated up to high temperature in order to burn said soot particles, feeding remaining soot particles to a soot filter, and passing the exhaust gases through an exhaust-gas filter. The exhaust gases which first entrain the soot particles are given a rotary motion so as to remove the same, and the soot particles are concentrated three-dimensionally by the action of centrifugal forces and, optionally, of a quiescent in-flowing zone or zones disposed in the flow path, and are passed from there to a soot filter. To initiate the combustion of newly arriving soot particles which are to be burned, one uses, instead of ignition electrodes, the heat of reaction of the already-burning soot particles and/or of the apparatus for carrying out the process, which has been heated up to high temperature.

I claim:

1. A process for the treatment of soot particles and the cleaning of exhaust gases of an internal combustion engine, which comprises: sweeping the exhaust gases with the soot particles past a plurality of ignition electrode wires heated up to high temperature for burning the soot particles, concentrating the soot particles by giving the exhaust gases extraining the soot particles a rotary motion, feeding remaining soot particles to a soot filter, and passing the exhaust gases through an exhaust filter.

2. The process according to claim **1**, which comprises providing a quiescent zone in the flow path of the exhaust gas, and concentrating the soot particles in the quiescent zone.

3. A process for the treatment of soot particles and the cleaning of exhaust gases of an internal combustion engine, which comprises: burning the soot particles entrained in the exhaust gases by utilizing the heat of reaction of burning soot particles, concentrating remaining soot particles by giving the exhaust gases entraining the soot particles a rotary motion, feeding remaining soot particles to a soot filter, and passing the exhaust gases through an exhaust filter.

4. The process according to claim **3**, which comprises providing an apparatus for cleaning the exhaust gases in the form of a casing having an inlet, an outlet and gas deflector plates disposed in said housing, initiating the burning of newly arriving soot particles which are to be burned by utilizing the heat of reaction of the already burning soot particles and the heat of the apparatus for cleaning the exhaust gas after the apparatus has been heated up to high temperature.

5. An apparatus for cleaning soot particles from exhaust gases of internal combustion engines, comprising a casing having an inlet, an outlet and a central region, an ignition electrode wire mounted in said casing for burning soot particles, gas deflector plates for swirling the exhaust gases about said central region and for concentrating the soot particles in said central region, filter means disposed outside said central region for filtering soot particles, and means for withdrawing the soot particles from said central region and feeding to said filter means.

6. The apparatus according to claim **5**, wherein said casing defines a central longitudinal axis and includes a first casing half having said inlet and a second casing half having said outlet, including a first deflection chamber, disposed in said casing, a flow cone disposed coaxially in said casing, said flow cone having gas deflector plates and a second deflection chamber, an ignition electrode, wire for burning soot particles, and an exhaust gas filter fitted downstream from said casing as seen in the flow direction of the exhaust gas.

7. The apparatus as set forth in claim **6**, wherein the second casing half (**5**) too is provided with gas deflector plates (**17**) in an annular space (**29**).

8. The apparatus as set forth in claim **6**, wherein the second casing half (**5**) has further gas deflector plates (**37**, which are disposed in the center of the second casing half (**5**).

9. The apparatus as set forth in claim **7**, wherein the casing (**1**) has a substantially rotation-symmetrical shape.

10. The apparatus as set forth in claim **9**, including a heating ring disposed in a plane in which said two casing halves are connected to each other, said electrode wire being disposed in said heating ring.

11. The apparatus as set forth in claim **10**, wherein there are provided in the heating ring (**9**) a first group of heating wires (**10**) running parallel to one another and a second group of heating wires (**11**) running parallel to one another, and the first group is disposed in the direction of flow upstream from the second group.

12. The apparatus as set forth in claim **11**, wherein the two groups of heating wires (**10, 11**) are offset relative to the longitudinal axes of the heating wires.

13. The apparatus as set forth in claim **12**, wherein the longitudinal axes of the heating wires (**10, 11**) are placed at right angles.

14. The apparatus as set forth in claim **13**, wherein a duct (**12**) is provided which from the interior of the flow cone (**6**) is brought out of the first casing half (**3**).

15. The apparatus as set forth in claim **14**, wherein a duct (**13**) running to the outside is located in the second casing half (**5**) and is in flow communication with the first deflection chamber (**4**).

16. The apparatus as set forth in claim **15**, wherein there is provided in the second casing half (**5**) a duct (**14**) running from the outlet (**22**) to the outside and disposed transversely to the outlet (**22**).

17. The apparatus as set forth in claim **16**, wherein the line (**22**) emerging from the second deflection chamber (**8**) is connected via an external line (**21**) to a line (**14**) running to an outlet (**22**) of the casing (**1**).

18. The apparatus as set forth in claim **17**, wherein a free edge (**24**) of the flow cone (**6**) is spread gradually outward.

19. The apparatus as set forth in claim **18**, wherein the inclination of the gas deflector plates (**7, 27**) can be adjusted to the planes of the heating wires (**10, 11**).

20. The apparatus as set forth in claim **19**, wherein said filter means is a soot filter attached between the outer ends of the ducts.

21. The apparatus as set forth in claim **20**, wherein there lies in each of the circuits of the heating wires (**10, 11**) of the heating ring (**9**) a switch which is operated by a control electronic system for the temperature-dependent switching on and off of the circuit concerned.

22. The apparatus as set forth in claim **21**, wherein, instead of heating wires, a duct-type structure with depth effect and composed of one or more substances put on for catalytic action is employed.

23. The apparatus as set forth in claim **22**, wherein the exhaust gas filter (**28**) is a catalyst.

24. The apparatus as set forth in claim **23**, wherein the catalyst includes a structure in which also the base material consists only of a catalytically active material.

25. The apparatus as set forth in claim **24**, wherein impacting, diffusion or electrostatic deposition are employed to enrich the soot particles.

* * * * *